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Invited Perspective: Implementation of Wastewater-Based Surveillance Requires Collaboration, Integration, and Community Engagement

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Wastewater-based surveillance (WBS) for infectious disease has significantly expanded during the COVID-19 pandemic. Huisman et al. add significantly to the use case for WBS by demonstrating that it can provide an independent basis for predicting disease transmission.[1] The authors show that the effective reproductive number (R_e) for SARS-CoV-2 can be estimated from WBS, potentially more cost effectively and rapidly than estimates based on clinical data, particularly when there are low rates of infection or disparities in clinical testing within a population. This paper is a timely contribution as the COVID-19 pandemic recedes, at-home COVID-19 test kits become more accessible, and clinical surveillance declines.

As public health systems consider institutionalizing WBS for the longer term, successful implementation will require additional development of several key elements. These elements include *a*) sustaining institutional partnerships to support use of WBS data, *b*) clarifying the integration of WBS and clinical data in pandemic surveillance systems, and *c*) expanding meaningful community engagement around WBS priorities, communications, ethics, and equity concerns (Figure 1).

Although the bulk of research on WBS for SARS-CoV-2 has focused on establishing techniques for producing high-quality data, many have noted that close partnerships between researchers, wastewater sample collectors, and public health decision makers are essential to successful use of this data.[2,3] Partnerships can help reconcile different spatial scales of data and action, as when sewersheds encompass several public health jurisdictions (i.e., span multiple cities or counties). Wastewater researchers can help public health professionals understand sources of uncertainty and more accurately interpret data collected via WBS. Ongoing interactions between WBS stakeholders at the facility (e.g., college campus) and municipal levels can coordinate messaging and public health action.[4]

In many locales, WBS stakeholders have developed partnerships to facilitate collaboration across institutions that had no prior frameworks for interaction. For example, in Monroe County, New York, wastewater agency staff, academic institutions, state agencies, and private consultants met biweekly throughout the pandemic to develop and coordinate WBS approaches, compare findings, and discuss potential public health responses to wastewater data trends.[5] Such partnerships are well poised to identify barriers to and resource needs for WBS over time. Research on how to establish, support, and sustain WBS partnerships may inform implementation of such efforts on a broader scale. Similar local partnerships have been highly impactful on other issues at the environment-health interface.[6]

Safford et al. urge using WBS "sensibly" in tandem with clinical case surveillance.[7] This recommendation includes strategically allocating limited resources between clinical testing and WBS, often under rapidly shifting pandemic conditions. Huisman et al. provide a concrete example of how such trade-offs may be made in practice. The authors suggest that at least three samples per week are needed to reliably identify R_e from wastewater. Although the cost and logistics of such frequent sampling may be a barrier to some municipalities, WBS is relatively cheap in comparison with randomized clinical testing for public health surveillance.[8] If WBS can provide real-time estimates of R_e at a lower cost, decision makers may choose to reallocate some resources from clinical testing to WBS. Also, WBS has the potential to inform clinical testing efforts. For example, a high R_e estimate based on WBS may motivate local health departments to distribute rapid testing kits or host pop-up testing sites within the sewershed.

Community engagement is essential to the design of WBS systems. Individuals who understand the significance of their

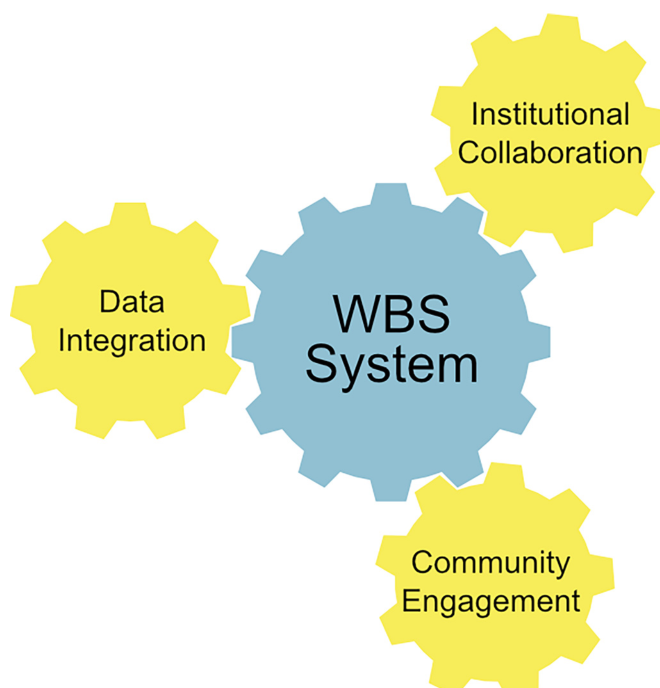

Figure 1. To date, WBS research has focused on developing sampling, analysis, and modeling approaches. An effective WBS system also requires research on how to support institutional collaboration, integration of WBS and clinical data, and community engagement throughout the process. Note: WBS, wastewater-based surveillance.

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community's WBS data may change their behavior to reduce personal risk based on reported trends. Community-based organizations may be best poised to act quickly on WBS data, for example, by engaging with hard-to-reach populations and providing resources for masking, clinical testing, and vaccination. Community engagement may also help ensure that implementation of WBS addresses health disparities by identifying appropriate scales for testing and locations where sampling could readily inform health-protective community-level actions. Engagement throughout the WBS process may help avoid inadvertently stigmatizing communities that are found to have higher rates of infection.

Community engagement around WBS can inform key stakeholders about the potential and limitations of this strategy and can help address community concerns, needs, and questions about the data collected. A proactive approach to community engagement can also foster dialog about how WBS data will be used and disseminated, which is key to its ethical use.[9] Engagement may also build support for devoting public resources to sustaining WBS systems between pandemics.

Because the public is largely unfamiliar with WBS, effective communication tools are a prerequisite for community engagement. These may include public data dashboards, K–12 curricula, and informal education programs (e.g., science museum exhibits, communications campaigns, health fairs). Environmental education and public health communication efforts are typically supported by separate resource streams, training, and professional development programs. Because WBS spans the fields of environmental and public health, there are limited funding opportunities, established outreach programs, and educators with relevant content-matter expertise. In addition, the "ick factor" of talking about sewage may deter educational efforts.[3] Finally, interest in WBS for COVID-19 may diminish as the pandemic recedes. Therefore, dedicated new programs may be needed to launch, support, and sustain effective WBS education.

Huisman et al.'s paper is a timely example of how WBS can inform public health decisions. To realize this potential, however, we need to develop decision support systems that integrate multiple disciplines, stakeholders, communities, and jurisdictions in WBS systems. Government agencies, academic institutions, researchers, and the private sector have invested deeply in developing WBS.[4,10] The technical feasibility and cost-effectiveness of WBS have been demonstrated.[7,8,11] To support full implementation of WBS, it is now essential to identify ways to sustain long-term partnerships that bridge the silos of health and environment, clarify appropriate roles for WBS data under varied pandemic scenarios, and engage diverse communities throughout the process.

The extensive research conducted on WBS to date has developed sampling methodologies, analysis approaches, and modeling using wastewater data. The next step is to translate these findings into action to inform decision systems, engage communities, and increase resilience to future pandemics.

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